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TRANSIMS Feedback

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TRANSIMS FEEDBACK

Transportation Research Board
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Outline

- *The role of feedback In TRANSIMS*
- *The mechanics of feedback in TRANSIMS*
  - *Information Pathways*
  - *Tools*
    - *Collator*
    - *Stratifier*
    - *Selector*
- *A familiar feedback controller: the thermostat*
- *Examples*
  - *stabilization: traffic assignment*
  - *working around input problems*
  - *modeling: mode preference*
- *Discussion:*
  - *using TRANSIMS for equity studies*
  - *forecasting with TRANSIMS*

TRANSIMS SOLVES A GAME

- *A million people decide*
- *the best course of action for themselves*
- *respecting the rules of the game (constraints imposed by infrastructure)*
- *in the context of everyone else's decisions*

TRANSIMS SOLVES A GAME - HOW?

- *A million people decide*
  - *Individuals are allowed to change goals:*
    - *activity times*
    - *activity locations*
    - *activity priorities*
    - *mode preference*
    - *routes*
- *the best course of action for themselves*
- *respecting the rules of the game (constraints imposed by infrastructure)*
- *in the context of everyone else's decisions*

TRANSIMS SOLVES A GAME - HOW?

- *A million people decide*
- *the best course of action for themselves*
  - *individuals can evaluate their performance on different alternatives using many metrics, such as*
    - *travel time (compared to free speed)*
    - *distance (compared to Euclidean distance)*
    - *time spent waiting for transit*
    - *time spent stopped in traffic*
    - *dollar costs*
    - *physical barriers crossed (rivers, tunnels)*
  - *each individual can evaluate overall costs idiosyncratically*
  - *individuals can minimize the cost across alternatives*
- *respecting the rules of the game (constraints imposed by infrastructure)*
- *in the context of everyone else's decisions*

TRANSIMS SOLVES A GAME - HOW?

- *A million people decide*
- *the best course of action for themselves*
- *respecting the rules of the game (constraints imposed by infrastructure)*
  - *travel times, time waiting, actual mass transit timetable are determined using microsimulation*
  - *capacity constraints on parking, vehicles can be imposed*
  - *travel mode, lane use, turn prohibitions, …, obeyed*
- *in the context of everyone else's decisions*

TRANSIMS SOLVES A GAME - HOW?

- *A million people decide*
- *the best course of action for themselves*
- *respecting the rules of the game (constraints imposed by infrastructure)*
- *in the context of everyone else's decisions*
  - *as with other games, the solution is a Nash equilibrium*
  - *each alternative can be tried holding others' behavior fixed*

TRANSIMS SOLVES A GAME USING FEEDBACK

- *A million people trying to decide*
- *the best course of action for themselves*
- *respecting the rules of the game (constraints imposed by infrastructure)*
- *in the context of everyone else's decisions*

Exact solution for Nash equilibrium is infeasible.

TRANSIMS uses feedback as a machine learning technique to drive the system toward Nash equilibrium :

- *Information about each individual's experiences is*
- *used to select those with suboptimal choices and*
- *aggregated to estimate the costs of other choices.*

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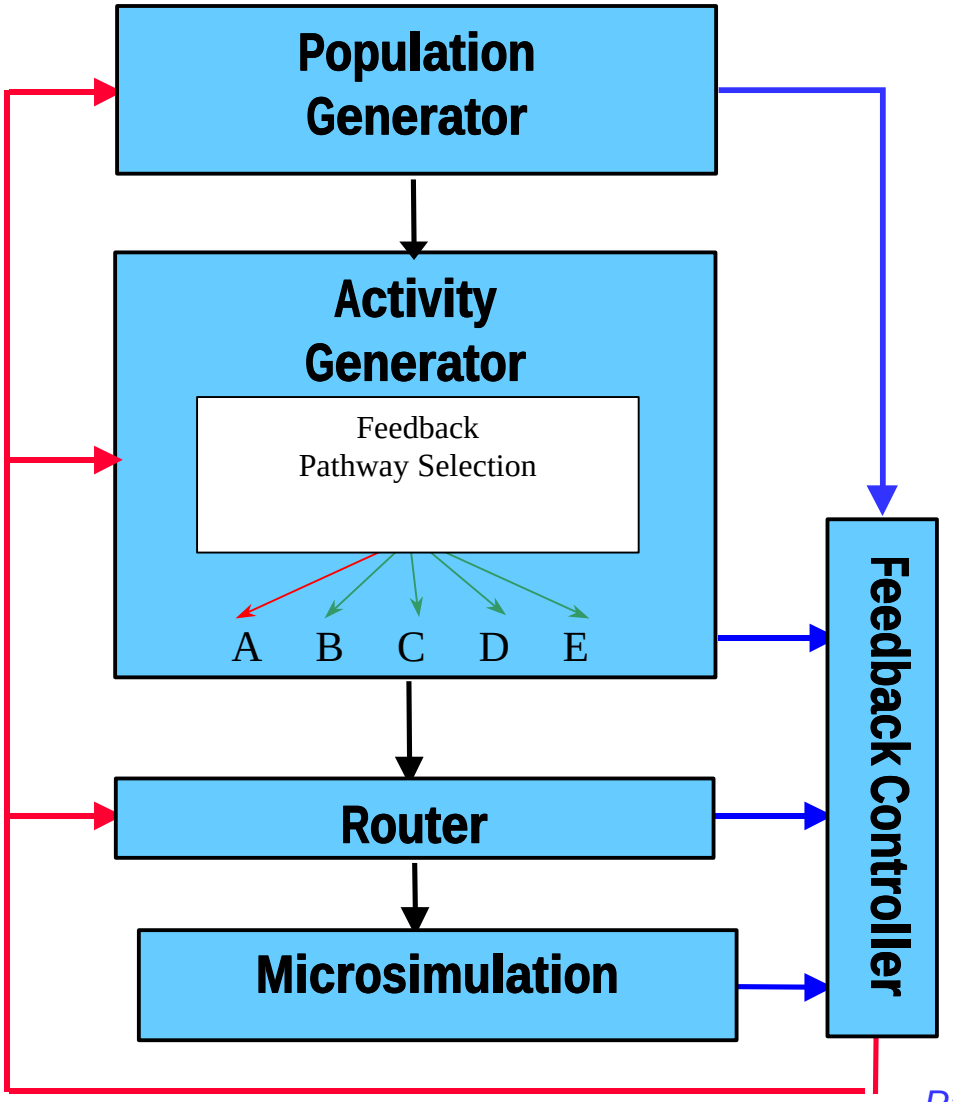
Mechanics of Feedback in TRANSIMS



Feedback Information Flows

- *Microsimulator to Router (traffic assignment)*
  - *Travel times (Link Delay File = Time Summary Output File)*
  - *Network data*
    - *Process link travel times*
    - *Transit schedule file*

- *Router to Activities (location choice)*
  - *Zone-zone travel times (by mode and time of day)*
  - *Identities of travelers who cannot fulfill desires*

- *Microsimulator to Activities (location choice)*
  - *Zone-zone travel times (by mode and time of day)*
  - *Identities of travelers who cannot fulfill expectations*

Link Delays

- *The default delay for a street link is the free speed delay.*
- *The actual delays calculated by the Traffic Microsimulator are used to provide more accurate information.*
- *The delay for walking or biking on a link is determined from the walking or biking speed.*
- *There are delays for entering and exiting transit vehicles.*
- *Process links can have a delay associated with them.*
- *Transit schedules can be updated to reflect actual times*
- *Noise can be added to the link delays. If the delay for a link is d and the specified noise percentage value is n, the reported delay will be in the interval (d-nd, d+nd).*

Zone - Zone Travel Times

The travel times file contains information about the travel times between zones and provides a mechanism to update the travel times used in the Activity Generator.

- *Format:*

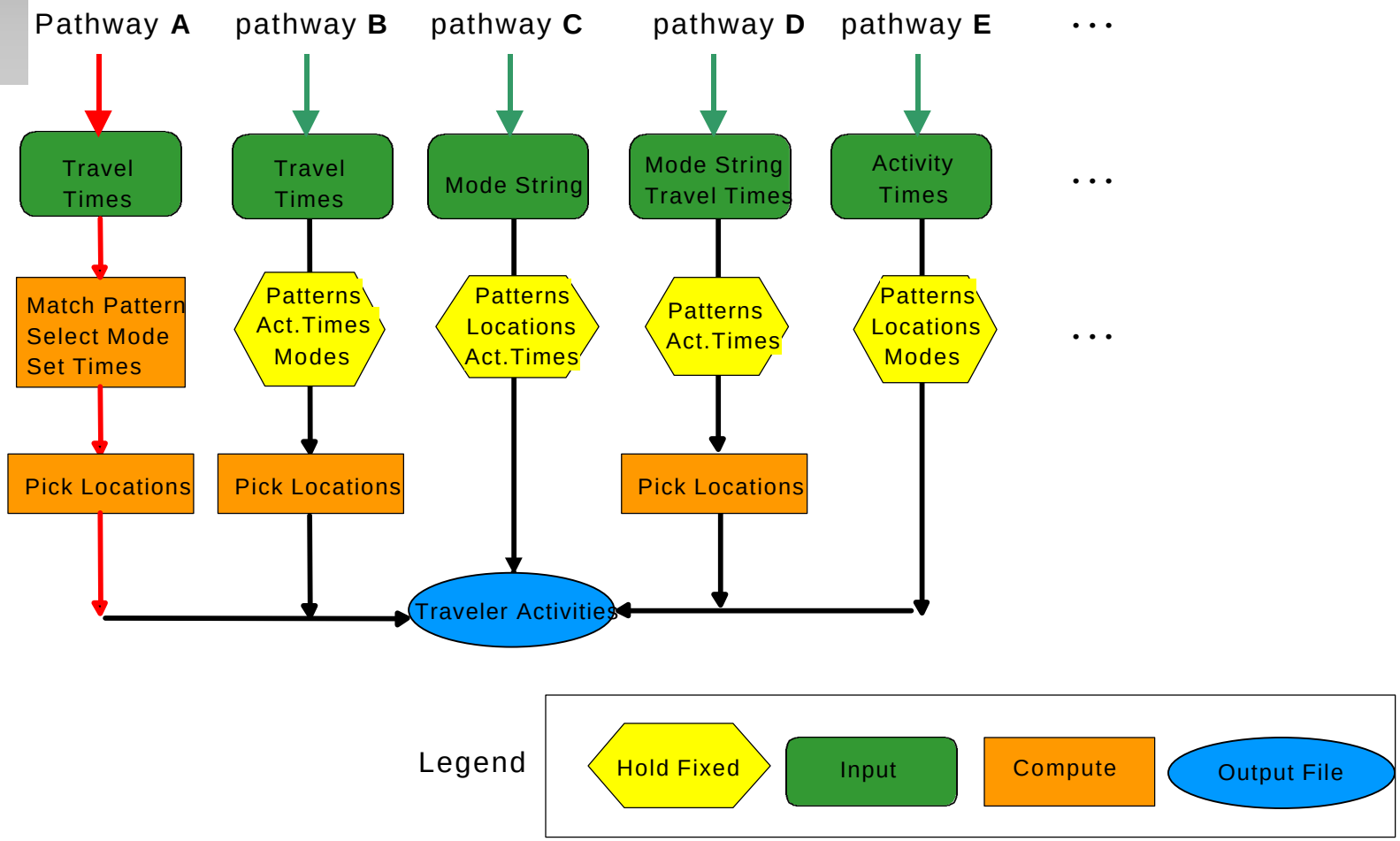
```
<zone1> <zone2> <mode number> <start time>
<end time> <travel time> <last update>
```

- *Example:*

```
3   7   2   300   600   900   18000
```

The travel time between zones 3 and 7 for mode 2 between the hours of 5:00 a.m. and 10:00 a.m. is 15 minutes (900 seconds). This entry was last updated at simulation time of 5:00 a.m. (18000 seconds).

Feedback Commands for the Activity Generator



Feedback Commands File

The feedback command file contains commands that tell the Activity Regenerator which activities to regenerate and what action to take for each specified activity.

- *Format:*

```
<Household Id> <Activity Id> <Command>
```

- *Example:*

```
1356    7   L
1358    2   LM   3
1379   10   M    2
1380   13   MS   3
1386    4   T    420   1040   0.5   1.0
1395    R
```

Feedback Commands

- *`L [<mode coefficient multiplier]` – change the location for the activity. The mode coefficient in the location choice methods will be multiplied by the optional command parameter.*
- *`M <mode value>` – change the mode for the activity to the integer mode value and make other activities on this home-to-home tour consistent with the new mode choice.*
- *`MS <mode value>` -- change the mode for the activity to the integer mode value.*
- *`LM <mode value>` – change the mode for the activity to the mode value and then change the location for the activity.*

Feedback Commands, *cont'd*

- *R – regenerate the entire activity list for the household by rematching with a survey household.*
- *T <start time> [<end time>] [<alpha parameter>] [<beta parameter>] – change the time for the activity to start time and if specified, end time with alpha and beta parameters on the time range.*
- *TY <activity type> – change the type for the activity to the specified type.*
- *U – update the activity times for the household. Activity times will be adjusted based on the latest travel time information.*

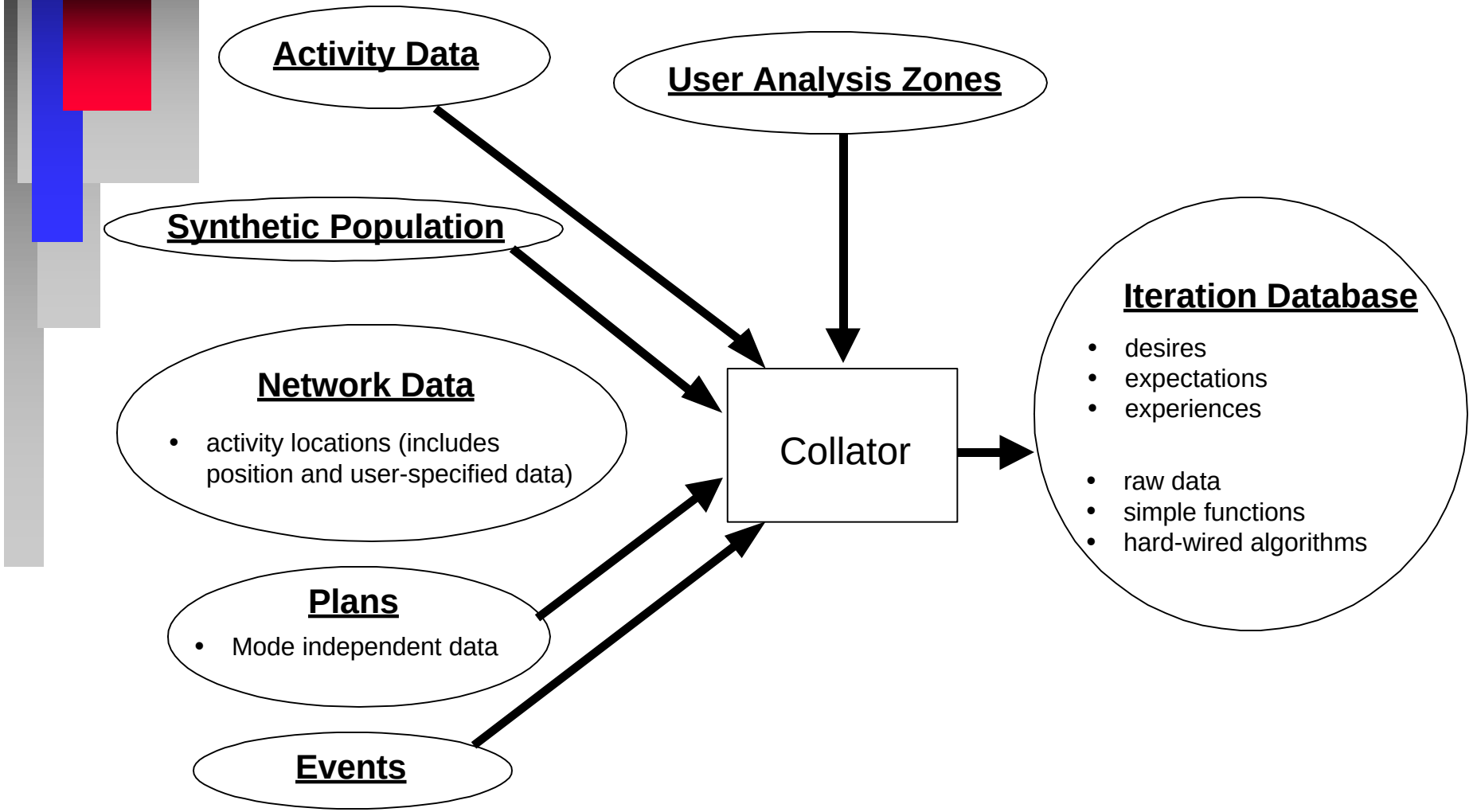
Activity and Time Priority

Description of time priorities.

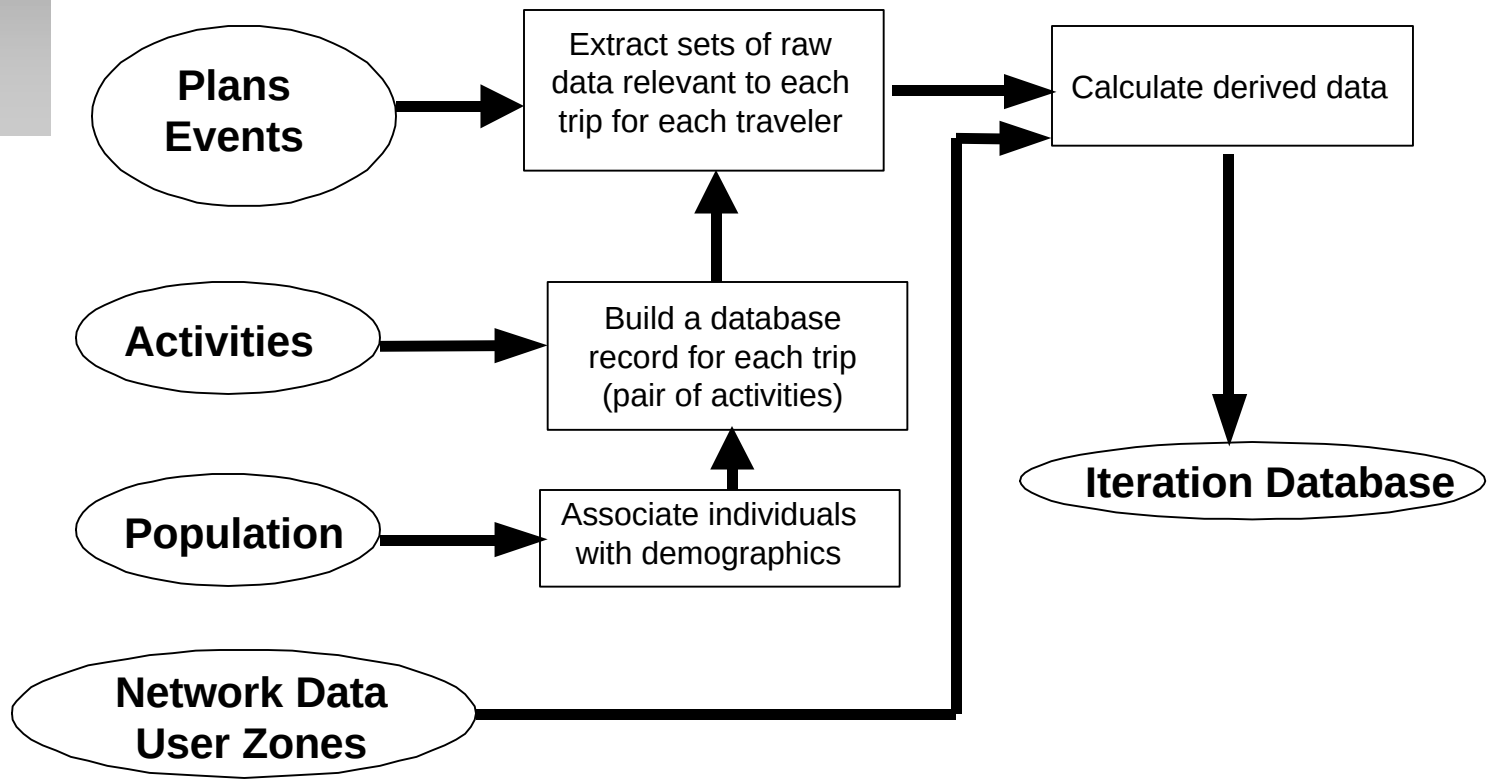
Time Priority	Important Time Start	Stop	Duration
0			
1	X		
2		X	
3	X	X	
4			X
5	X		X
6		X	X
7	X	X	X

Field	Description	Allowed Values
`Household ID`	Each household has a unique household ID. Each Group Quarters is given one household ID. These numbers are assigned in the population file.	integer
`PersonID`	Each person is given a unique ID in the population file.	integer
`ActivityID`	Each activity in the household has a unique ID.	integer >0
`Activity Type`	The definition of activity types may vary. Meaning of the integer value must be specified for each activity set.	integer: 0 through n: Example: 0 = Home 1 = Work 2 = Shop 3 = School 4 = Visit 5 = Other 6 = Serve Passenger
`Activity Priority`	Priority that indicates the importance of the activity. Higher values mean that the activity may be skipped. Lower values mean that the activity must be done.	integer: 0 – 9

Data Flow in the Collator



Collator Algorithm



Collator Output: Raw Data

- *From Population Files:*
  - *person or household demographics*
- *From Activity Files:*
  - *type, priority, desired times, participants, mode*
- *From Plan Files:*
  - *expected travel times, modes*
- *From Event Files:*
  - *actual travel times and distances, number of stops, time stopped, anomalies*
- *From Network Data*
  - *activity location properties*

An Event File

ACCELS	ANOMALY	DISTANCE	LEG	LINK	LOCATION	NODE	ROUTE	SIGNALS	STATUS	STOPPED
0	0	0	1	318210	848210	0	0	0	67108924	0
0	0	0	1	318210	848210	0	0	0	67108920	0
0	0	0	1	318210	848210	0	0	0	67108924	0
0	0	0	1	318210	738210	0	0	0	16424	0
0	0	0	2	318210	738210	0	0	0	16396	0
0	0	0	2	318210	738210	0	0	0	28676	0
0	0	135	2	318210	738210	0	-1	0	21252	0
0	0	135	2	318210	738210	0	-1	0	23812	0
0	0	0	2	318210	738210	0	-1	0	25860	0
1	0	150	2	318210	0	58210	-1	0	1286	0
1	0	375	2	318200	0	28200	-1	1	1286	10
1	0	600	2	317270	0	57270	-1	1	1286	11
1	0	825	2	317260	0	57260	-1	1	1286	11
1	0	1050	2	317250	0	57250	-1	1	1286	11

STOPS	TIME	TIMESUM	TRAVELEI	TRIP	TURN	USER	VEHICLE	VEHTYPE	VSUBTYP	YIELDS
0	0	0	13072	1	0	0	0	0	0	0
0	26265	0	13072	1	0	0	0	0	0	0
0	26265	0	13072	2	0	0	0	0	0	0
0	26275	0	13072	2	0	0	0	0	0	0
0	26275	0	13072	2	0	0	0	0	0	0
0	26276	0	13072	2	0	0	0	0	0	0
0	26276	0	13072	2	0	0	13052	1	0	0
0	26276	0	13072	2	0	0	13052	1	0	0
0	26276	0	13072	2	0	0	13052	1	0	0
0	26282	6	13072	2	0	0	13052	1	0	0
0	26301	25	13072	2	0	0	13052	1	0	0
0	26312	36	13072	2	0	0	13052	1	0	0
0	26321	45	13072	2	0	0	13052	1	0	0
0	26331	55	13072	2	0	0	13052	1	0	0

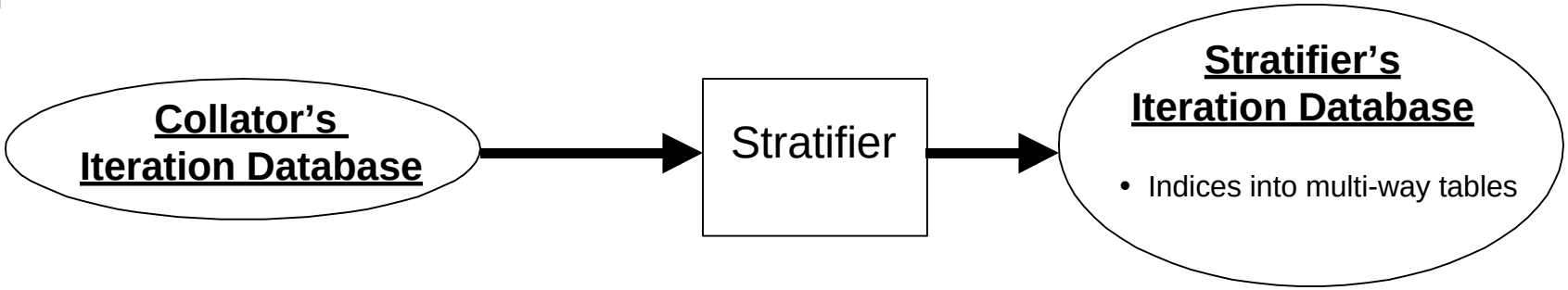
Collator Output: Derived Data

- *Start/End in user specified region*
- *Cross from one user specified region to another*
- *Euclidean distance between origin and destination*
- *Does the traveler drive a passenger on any leg of the trip?*
- *Create a string of characters describing the mode used for each leg, e.g. “wcwttw”*
- *Count the number of legs in a trip*
- *Count the number of legs using a particular mode in a trip*
- *Sum the distance, time, or just the time spent walking or waiting*
- *Calculate the effective speed through the network*
- *Did the traveler finish the trip?*
- *Calculate simple functions of other fields (difference, ratio)*

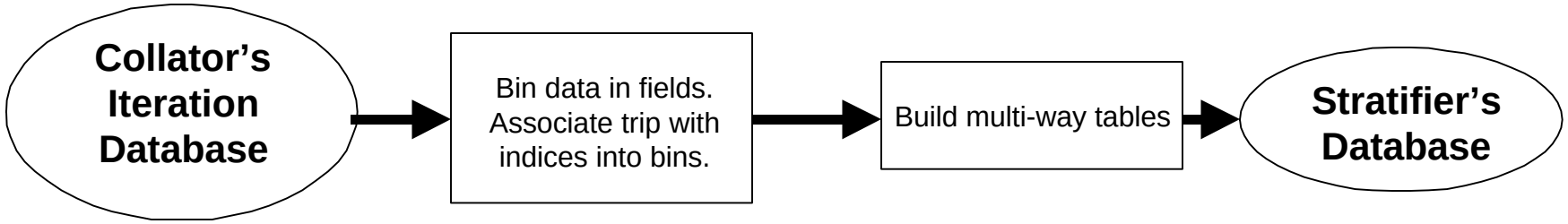
An Iteration Database

HH_ID	PERSON_	RHHINC	AGE	MODE_P	DRIVES_F	TRIP_ID	START_A(	END_ACC	NUMLEGS	TIME	T_TOTAL	FINISH_TRIP
13022	13072	75600	37	2	FALSE	2	848210	833650	3	27161	896	TRUE
13022	13072	75600	37	2	FALSE	4	833650	848210	3	58058	821	TRUE
13022	13072	75600	37	2	TRUE	6	848210	843567	3	67963	749	TRUE
13022	13072	75600	37	2	TRUE	8	843567	848210	3	74106	794	TRUE
13022	13073	75600	37	2	FALSE	2	848210	856421	3	26298	470	TRUE
13022	13073	75600	37	2	FALSE	4	856421	853545	3	43824	500	TRUE
13022	13073	75600	37	2	FALSE	6	853545	854604	3	44055	230	TRUE
13022	13073	75600	37	2	FALSE	8	854604	848210	3	61672	851	TRUE
13022	13073	75600	37	2	FALSE	10	848210	843567	3	67963	3587	TRUE
13022	13073	75600	37	2	FALSE	12	843567	848210	3	74106	1445	TRUE
13022	13074	75600	17	2	FALSE	2	848210	865445	3	39177	542	TRUE
13022	13074	75600	17	2	FALSE	4	865445	848210	3	68270	500	TRUE

Data Flow in the Stratifier

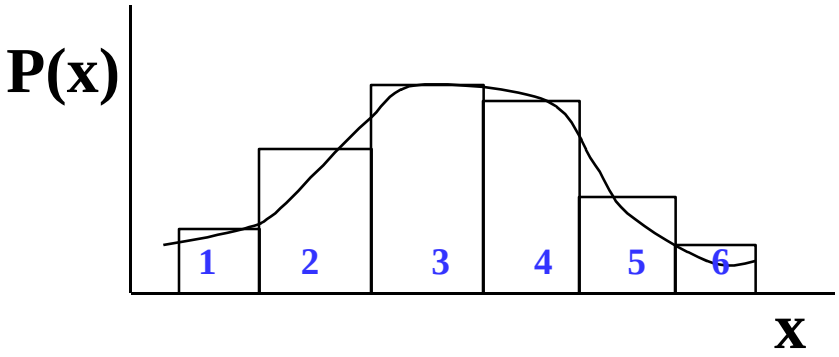


Stratifier Algorithm



Stratification

- *Discretize (bin) univariate data*



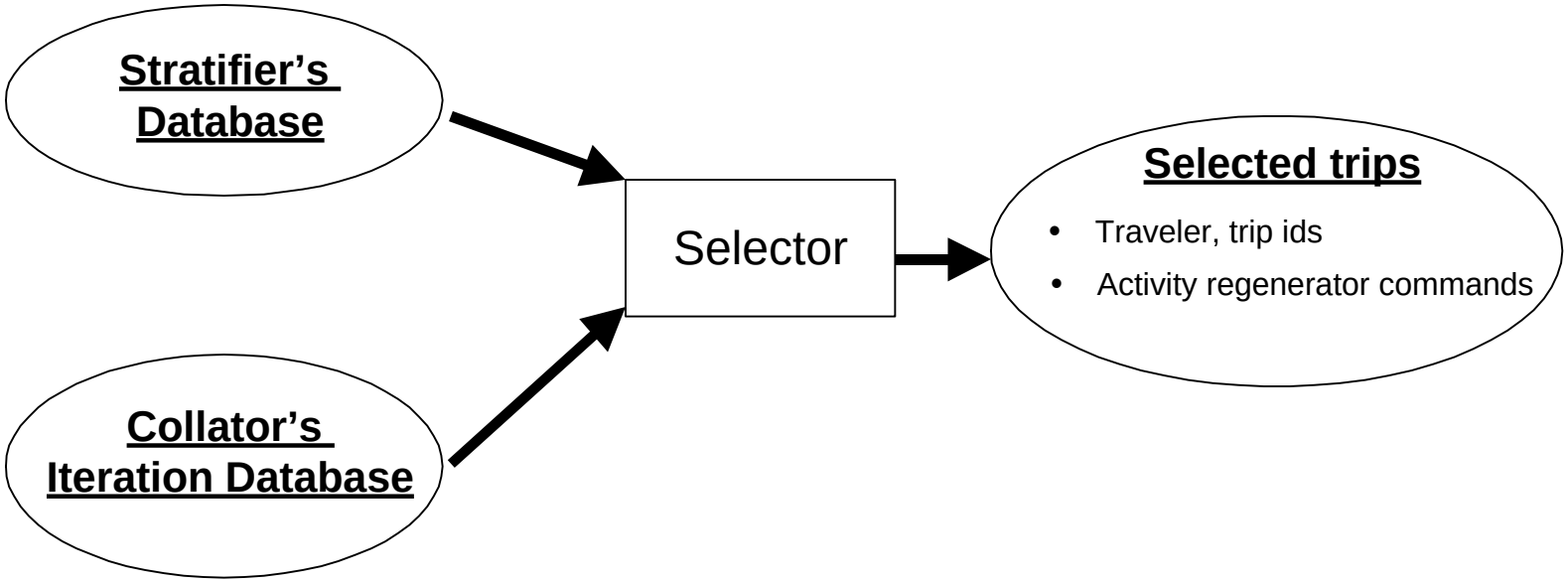
- *Make multi-way table. Each cell corresponds to a set of bins.*

(x, y)				
	(1, 1)	(1, 2)	(1, 3)	(1, 4)
	(2, 1)	(2, 2)	(2, 3)	(2, 4)
	(3, 1)	(3, 2)	(3, 3)	(3, 4)

Stratifier Database

TRAVELEI	TRIP	nothers	modepref	atype	distance	ssouth	esouth	srail	erail	STRAT_0
13000	2	0	1	5	4	0	0	0	0	265
13000	4	0	1	1	2	1	0	1	0	1521
13000	6	0	1	1	4	1	0	1	1	3873
13000	8	0	1	1	4	1	1	0	1	3313
13001	2	0	7	3	3	0	1	0	0	759
13001	4	0	7	0	3	0	1	1	1	4095
13002	2	0	7	3	3	0	1	0	0	759
13002	4	0	7	0	3	0	1	1	1	4095
13003	2	0	1	2	4	0	1	0	1	3041
13003	4	0	1	5	4	0	1	0	1	3065
13003	6	0	1	5	4	0	0	0	0	265
13003	8	0	1	5	4	1	1	1	1	4465
13003	10	0	1	2	4	0	1	0	0	801
13003	12	0	1	5	4	0	1	1	1	4185
13004	2	2	1	5	4	0	0	0	0	265
13004	4	2	1	0	4	1	1	1	1	4425
13005	2	0	1	5	4	0	0	0	0	265
13005	4	0	1	4	2	1	0	1	0	1545
13005	6	0	1	5	4	1	1	1	1	4465
13005	8	1	1	5	4	0	0	0	0	265
13005	10	1	1	0	4	1	1	1	1	4425
13006	2	0	1	1	4	0	1	0	1	3033
13006	4	0	1	5	4	0	1	0	1	3065
13007	2	2	1	1	4	0	1	0	1	3033
13007	4	2	1	4	4	0	0	0	0	257
13007	6	2	1	1	4	1	1	1	0	2193
13007	8	2	1	5	4	0	1	1	1	4185

Data Flow in the Selector



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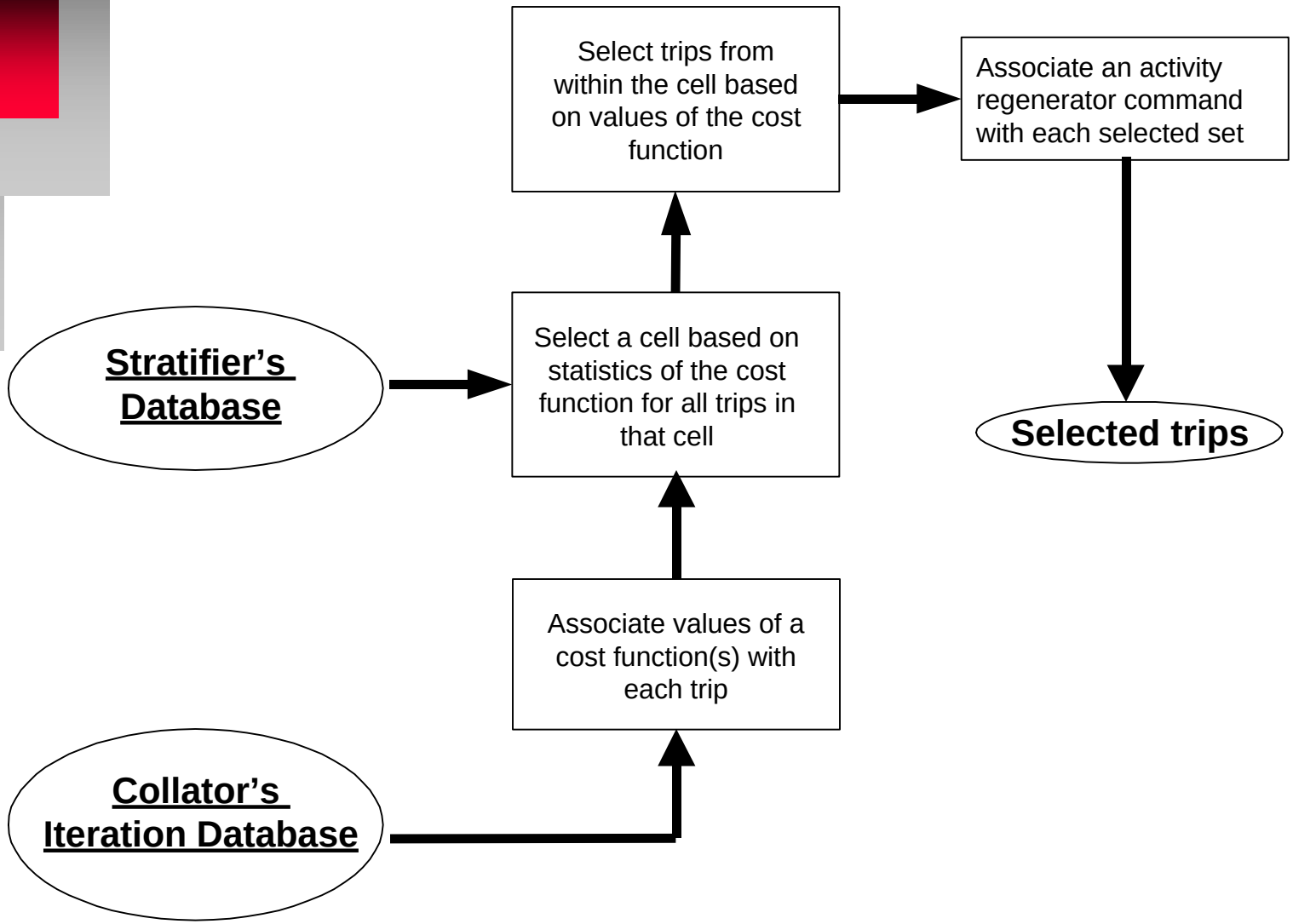
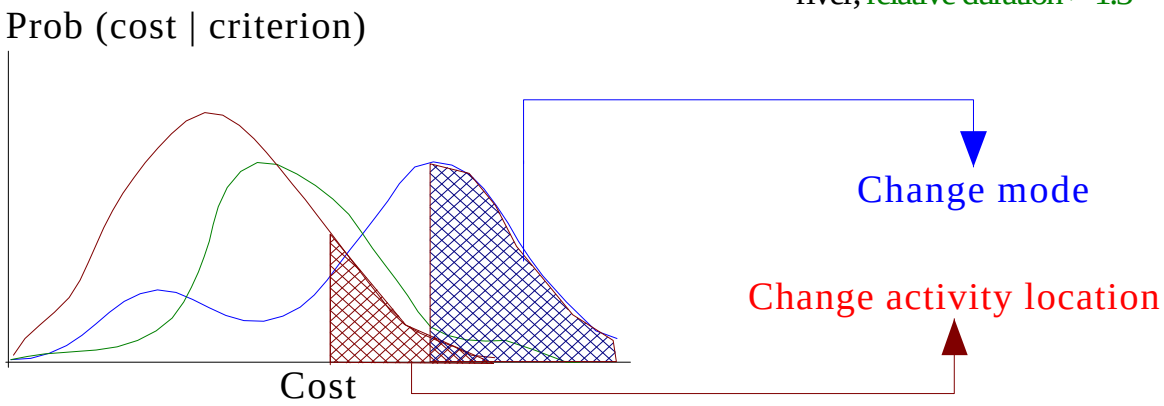


Collator + Stratifier + Selector = Feedback

The iteration database:

Traveler	Income	Mode	>1 hour?	Cross river?	Relative duration	. . .
291362	$25K	bus	no	yes	1.2	. . .
291363	$34K	car	yes	no	1.6	. . .
291364	$42K	car	no	yes	1.1	. . .
291365	$ 0K	walk	no	no	1.0	. . .
291366	$38K	car	yes	yes	2.3	. . .
291367	$45K	bus	yes	no	1.4	. . .
291368	$30K	car	yes	yes	1.3	. . .

Selection criterion:	Selects travelers:
bus trips with income >$40K	291367
short trips crossing the river	291362 291364
long car trips not crossing the river, relative duration > 1.3	291363



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Thermostats as Feedback Control Systems

- *Compare to model-based predictive control*
  - *Model (predict) temperature as a function of solar radiation, wind speed, outdoor temperature, fuel to furnace, etc.*
- *Both work on macroscopic quantities*
- *Measure temperature*
  (simulation: micro-model of heat transfer)
- *Add an open window - which one adapts better?*
- *Add a constraint - which one is easier to adjust?*
  - *Need to add a control?*
- *Predict temperature in a different room*
  - *Need to know constraints*
- *Find best place to locate furnace intake*

Thermostats as Feedback Control Systems

- *Alice builds a model to estimate temperature T given:*
  - *outdoor temperature*
  - *amount of sunshine*
  - *# people in room*
  - *furnace control setting*

- *Bob feeds information back*
  - *from a thermometer*
  - *to the furnace controller*

Thermostats as Feedback Control Systems

- *Neither system can be used without providing a constraint: the desired temperature T*.*
  - *Alice*
    - *measures independent variables (sunshine, outdoor temp., # people)*
    - *picks the best furnace setting*
  - *Bob*
    - *defines the information to be fed back (difference between T and T*)*
- *Both systems work on macroscopic measurements (temperature, not molecular velocities)*

Thermostats as Feedback Control Systems

- *Change infrastructure:*
  - *open window*
  - *add skylight*
  - *add room*
- *Alice must build new model*
- *Bob does not need to change anything*

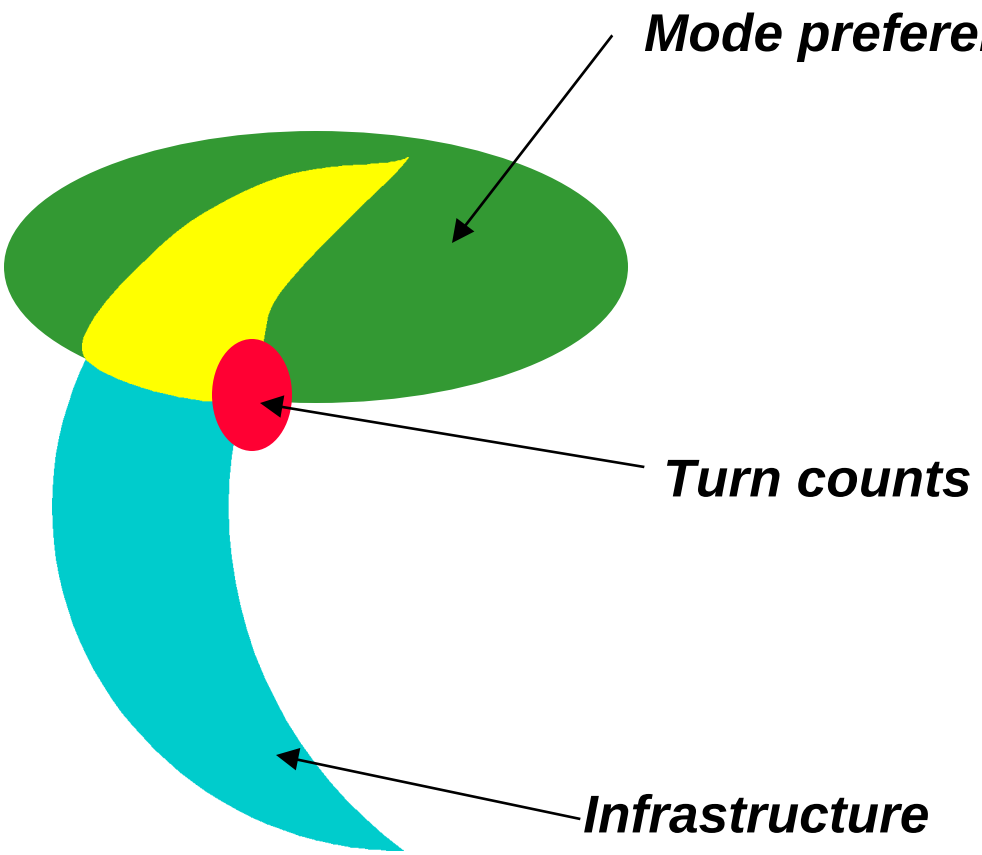
Thermostats as Feedback Control Systems

- *Pose new questions:*
  - *1) what is temperature in a different location?*
  - *2) what is relative humidity?*
  - *3) how much fuel is required for the furnace?*
- *Alice must*
  - *1) build new models*
  - *2) make new measurements*
  - *3) make assumptions about weather patterns*
- *If Bob uses micro-simulation, he must*
  - *1 - 2) make no changes*
  - *3) make assumptions about weather patterns*

Thermostats as Feedback Control Systems

- *What will Bob's micro-simulation look like?*
  - *estimate heat, water vapor flow through the building*
  - *build physical constraints into the simulation*
  - *model infrastructure with boundary conditions*
  - *efficient, scalable, works at a very detailed level*
- *Note: don't need molecular scales correct, just averages over macro quantities*
- *Note: equilibrium/steady-state*

Effect of Constraints on Possible Results



Questions For Modeling With TRANSIMS

- *How can the selection process be used for equity studies?*
- *Design a feedback system to*
  - *fit a given mode split*
  - *fit a particular fraction of trips crossing a river*
  - *fit traffic count data*
- *How might the designs above introduce bias into uncontrolled variables? How do they handle correlated inputs?*
- *What additional data or capabilities might be required to*
  - *study the effects of downtown parking prices*
  - *estimate the mode split for 2010*
  - *model the effect of employer incentives for carpooling*

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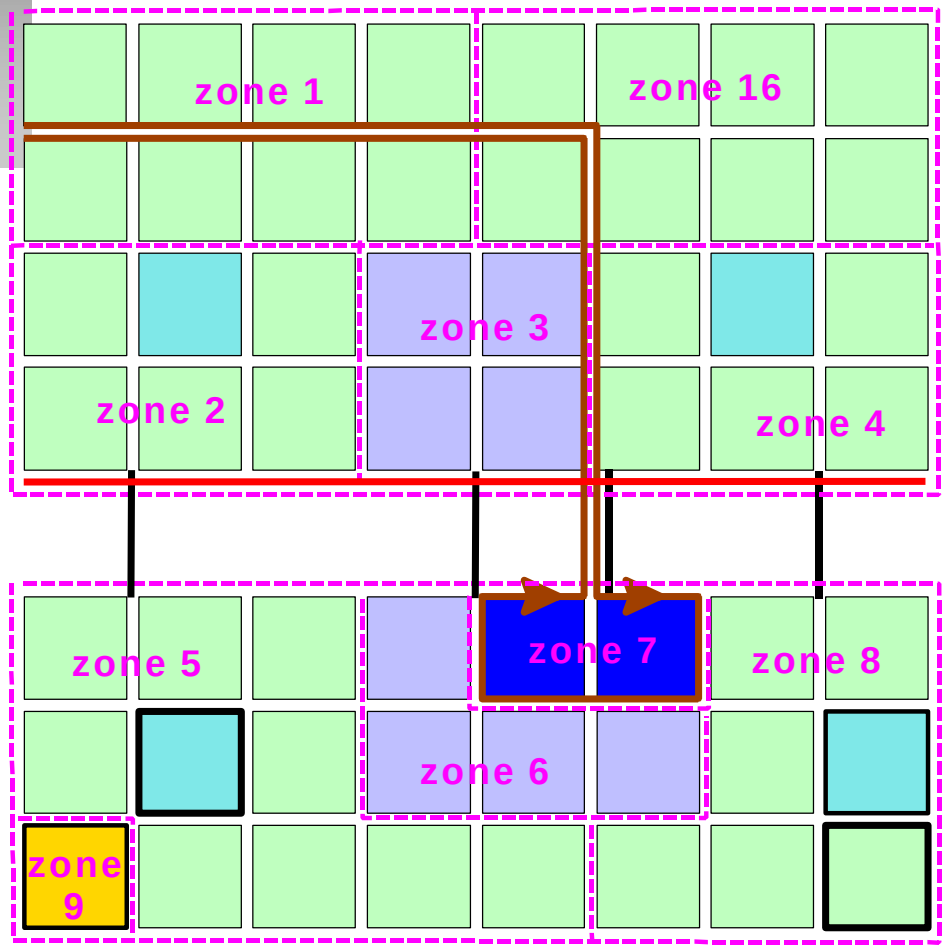
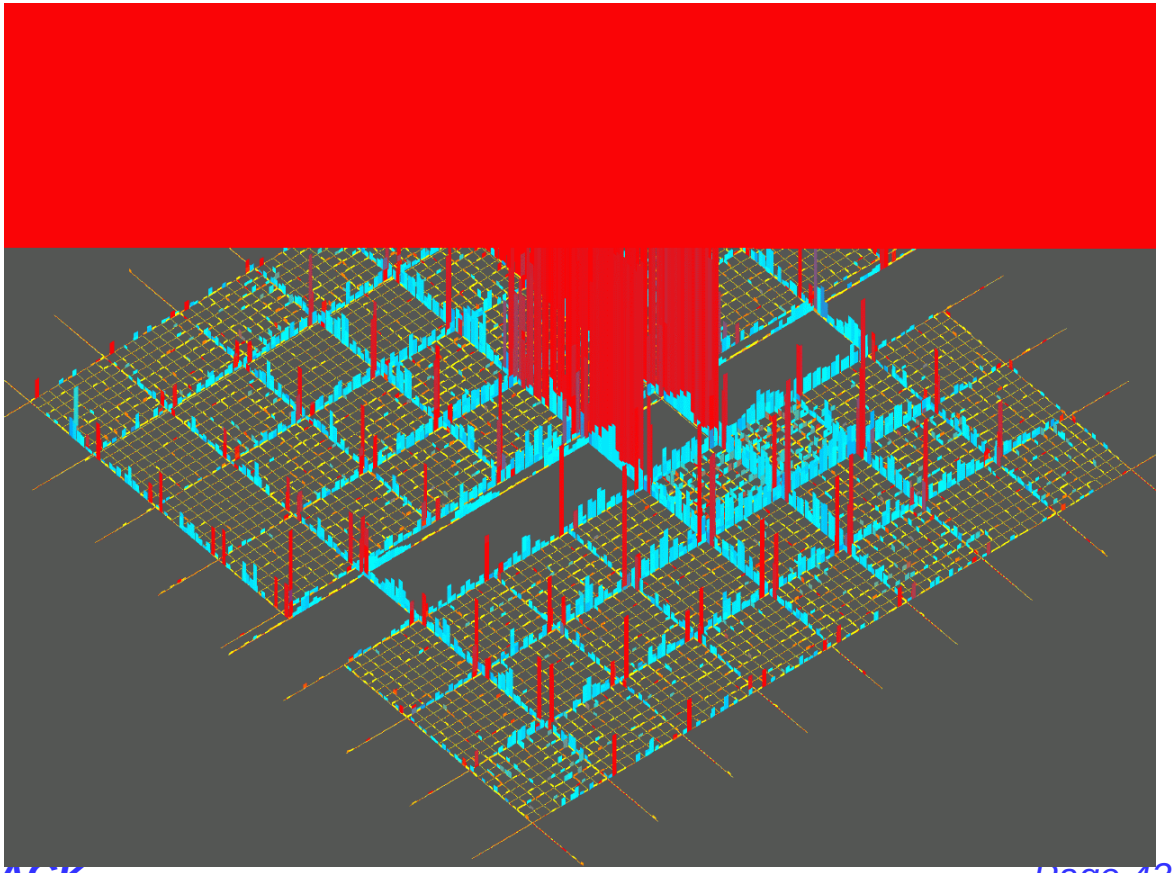
The Bignet Network



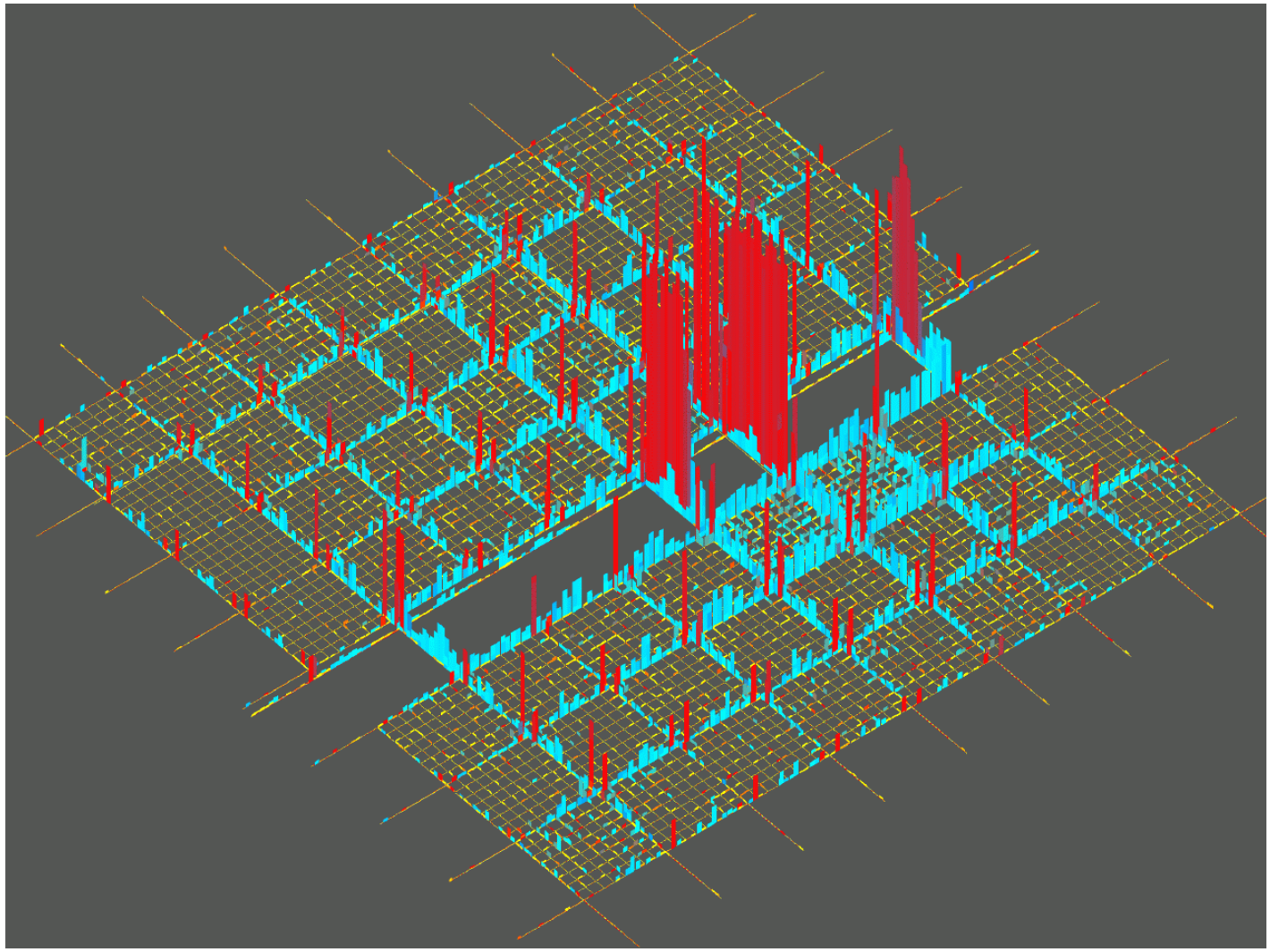
- Heavy Commercial
- Light Commercial
- Heavy Industrial
- Light Residential
- Mixed: Res./Comm.
- Freeway
- Light Rail
- Bridge
- Zone Boundary

Example: Traffic Assignment in Bignet

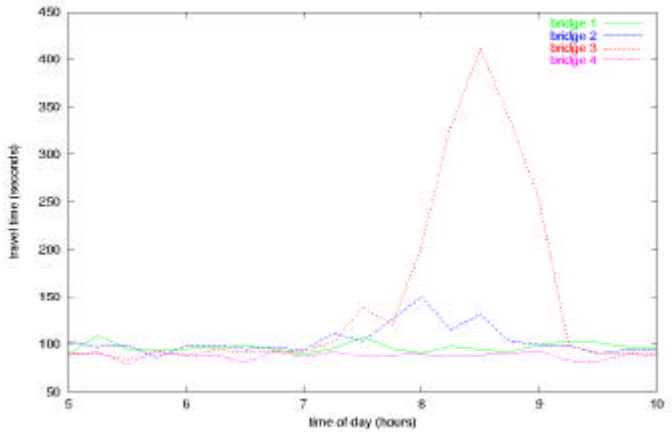
- *Run Activity Generator*
- *Run Router (free speed delays)*
- *Run Microsimulator, collecting time summary output.*
- *Re-run Router, with noise*
- *Re-run Microsimulator, collecting the same data*

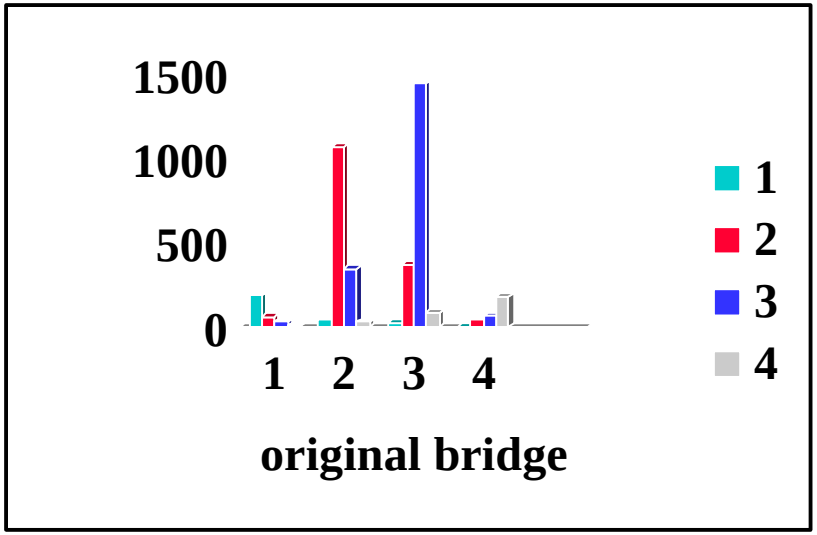


Effects of Travel Time Information on Routing



What Happened?





Activity Problem File

PROBLEMS DETECTED	SOLUTIONS
1) Failed to find driver for shared ride	*Pick new survey household*
2) Failed to match synthetic w/ survey	*Inspect tree*
3) Arrived too late	*Adjust time, location*
4) Failed to adjust shared ride times	*Turn off time cascading*
5) No vehicle for driving trip	*Create vehicle*
6) Incomplete match synthetic w/ survey	*Pick new survey household*
7) Underage driver	*Change mode*
8) Wrong age for school activity	*Change activity type to college or day care*

Router Problem File

PROBLEMS DETECTED	SOLUTIONS
1) No path	*Examine network, including transit schedule Check time constraints*
2) Invalid time	*Change times*
3) Invalid shared ride (Driver/passenger activities don't match up)	*New survey household; new modes*
4) Invalid shared ride time	*Change time, location of passenger and driver activities*
5) Origin parking lot = destination parking lot	*Not a problem*

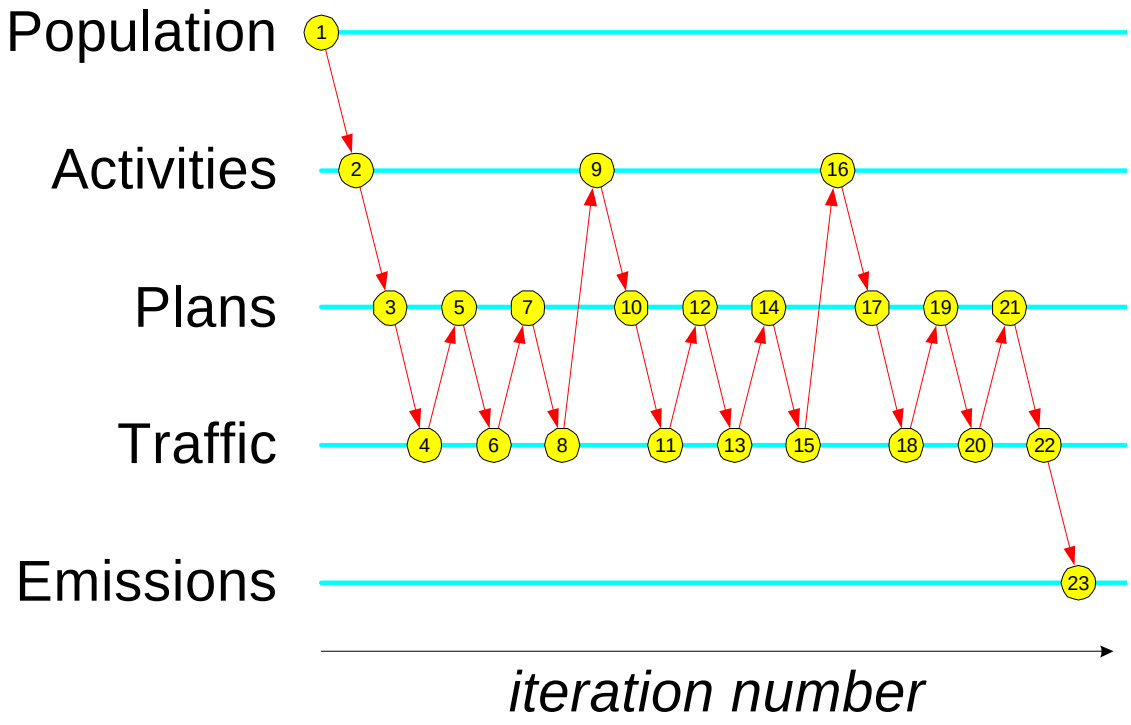
Example: Mode split in bignet

Bignet is a notional city with fixed land use, transit routes, and a geographic barrier.

- *Two population sizes:*
  - *small: 37789 households; 70355 people*
  - *large: 60452 households; 119998 people*
- *Two mass transit schedules*
  - *frequent: every 10 minutes, 24 hours a day*
  - *reduced: every 20 minutes, 6 AM - 8 PM*
- *Dollar costs imposed for*
  - *CBD - entering central business district in auto (parking)*
  - *RIVER - crossing river in auto (toll)*

Mode Split Iterations

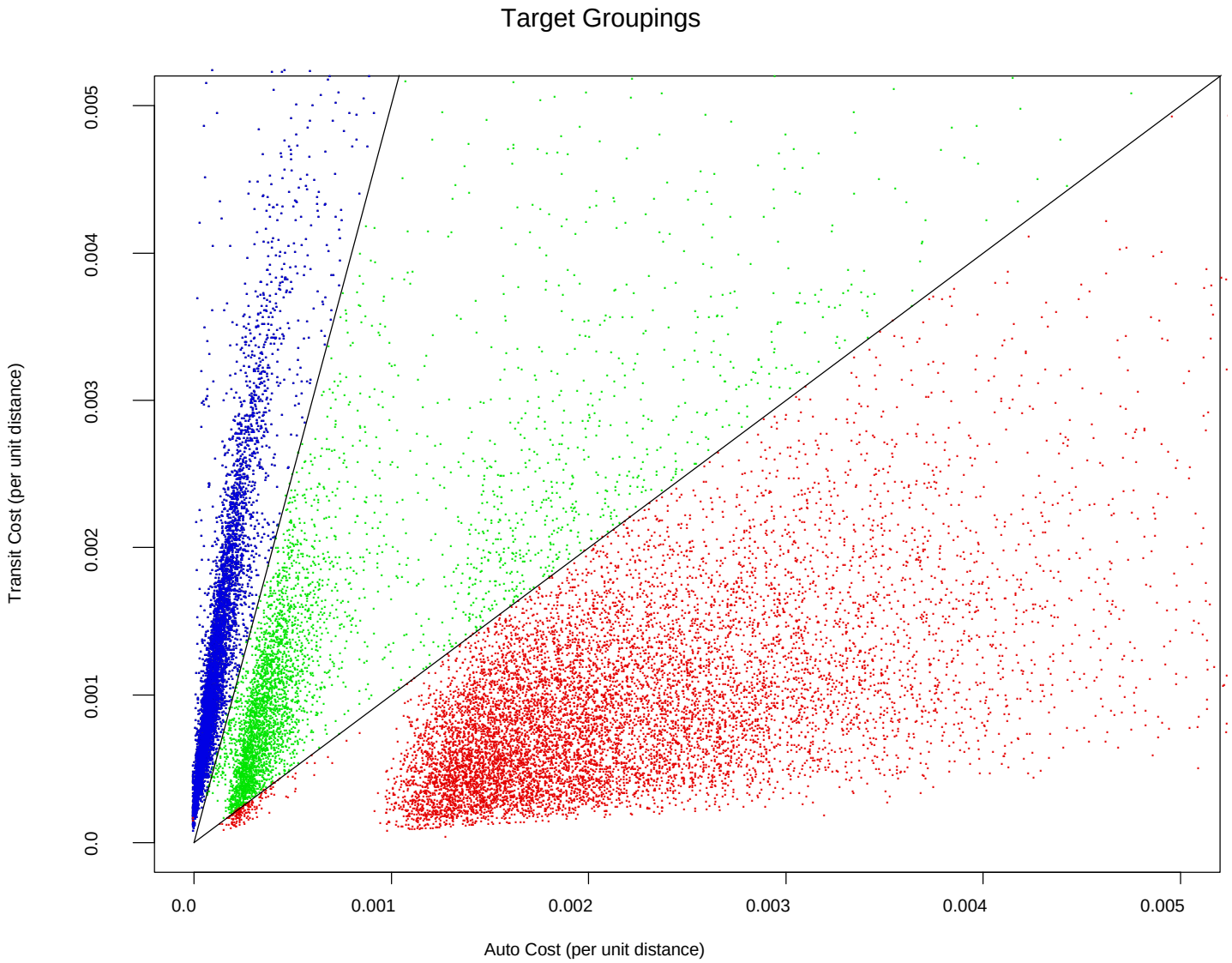
- *Create population, assign activities and modes from survey*
- *Route population*
- *Perform traffic assignment iterations to estimate travel times*



Mode Split Analysis

- *Stratify population to create low-entropy conditional distributions (easier to estimate)*
- *Find distribution of travel times for each cell of table (includes both transit and auto modes)*
- *Evaluate travel times for the alternative mode for a small (10%) sample of each cell's population*
- *Pick stratification variables that best distinguish groups*
- *Either*
  - *Choose an overall target mode split*
- *Or*
  - *Choose a set of parameters weighting $ costs and time*
- *Estimate the fraction preferring transit in each bin*
- *Projection into future requires generalizing something: constraints, cost function, ???*

Comparing Costs



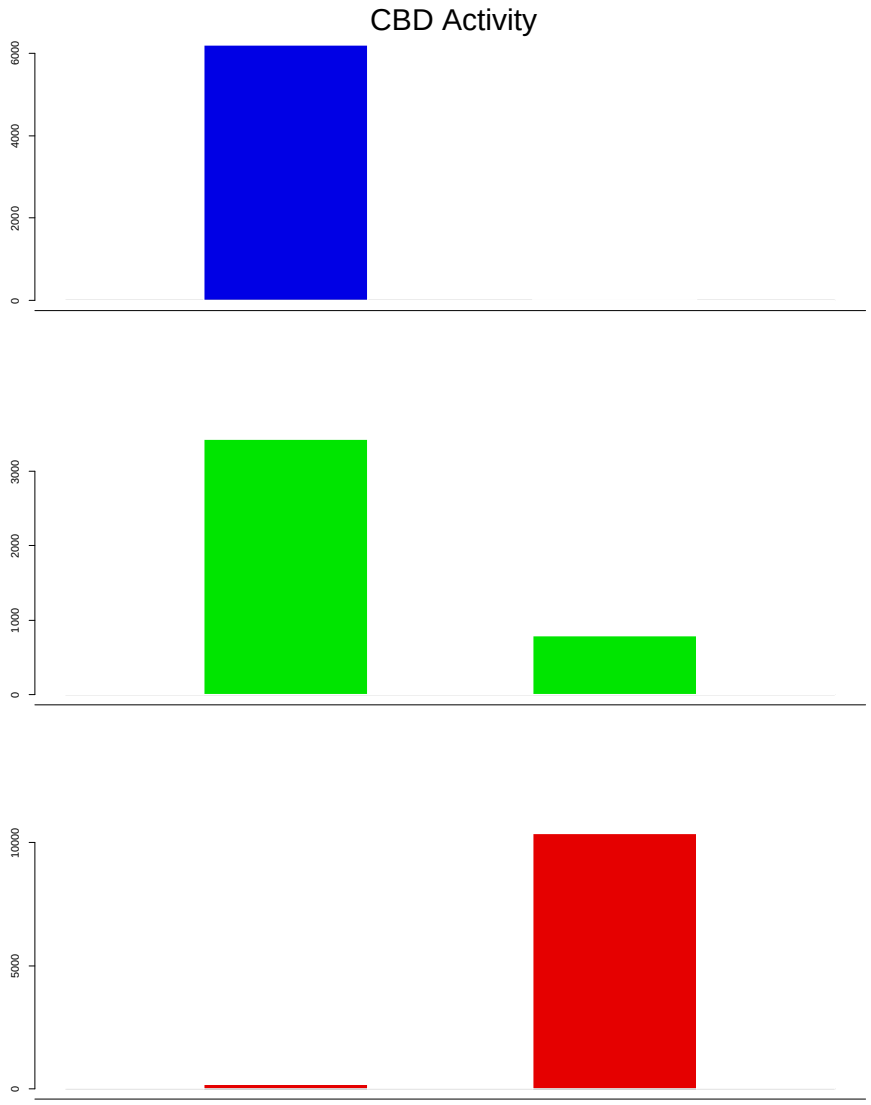
Choosing Stratification Variables

- *Variables likely to be relevant*
  - *trip ends in CBD* *(SEL_USE_ENDS_IN_REGION 1,1)*
  - *trip crosses river* *(SEL_USE_CROSS_BOUND 2)*
  - *age* *(SEL_USE_AGE 1)*
  - *income* *(SEL_USE_HHINCOME 1)*
- *Correlation between groups in these variables*
  - *group 1 much prefers auto*
  - *group 2 slightly prefers auto*
  - *group 3 prefers transit*

	1 and 2	1 and 3	2 and 3
CBD	0.97	-0.48	-0.28
RIVER	-0.07	0.43	0.87
AGE	0.96	0.99	0.95
INCOME	0.93	1.00	0.95

Choosing Stratification Variables, cont'd

Anti-correlation between variables indicates which best distinguishes groups.



Stratification

- *example stratification by CBD and river (small or large population, either transit schedule)*

	Don't end in CBD	*End in CBD*
Don't cross river	*40%*	*24%*
Cross river	*12%*	*24%*

Percentage of trips in each cell

Mode preferences: small population, frequent transit

	Don't end in CBD	*End in CBD*
Don't cross river	*99%*	*9%*
Cross river	*92%*	*5%*

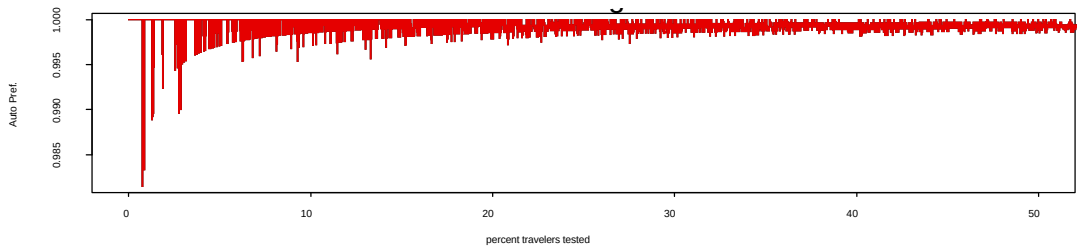
Percentage preferring auto

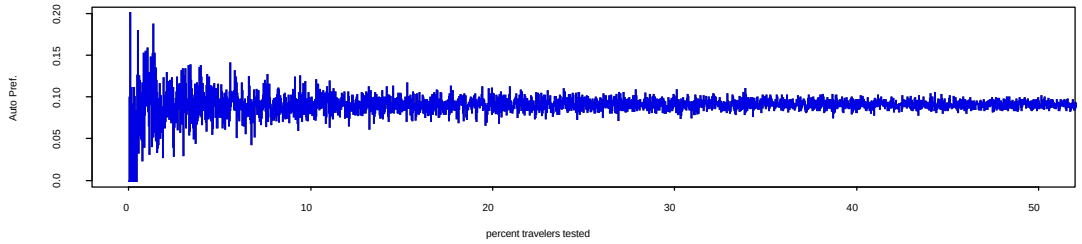
Overall percentage of total trips preferring auto:

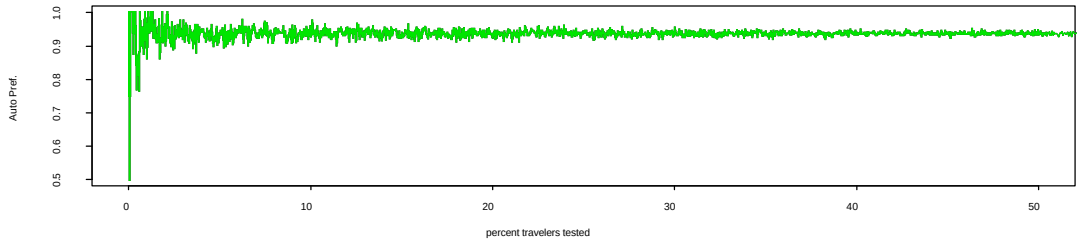
99% * 40% + 9% * 24% + 92% * 12% + 5% * 24% ~ 54%

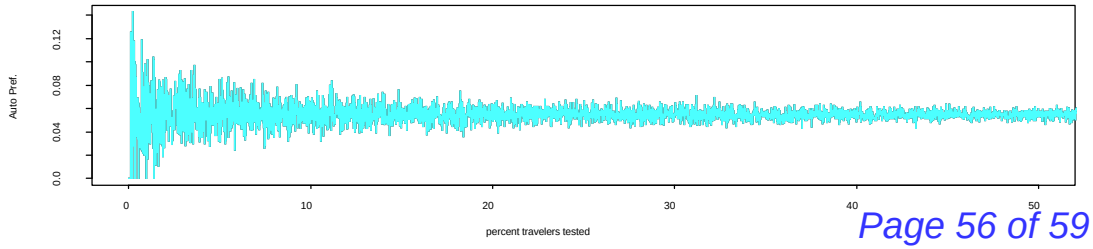
Small population, frequent transit

Cross River?	End in CBD?
No	No
No	Yes
Yes	No
Yes	Yes









Small population, reduced transit

	Don't end in CBD	*End in CBD*
Don't cross river	*99%*	*20%*
Cross river	*93%*	*5%*

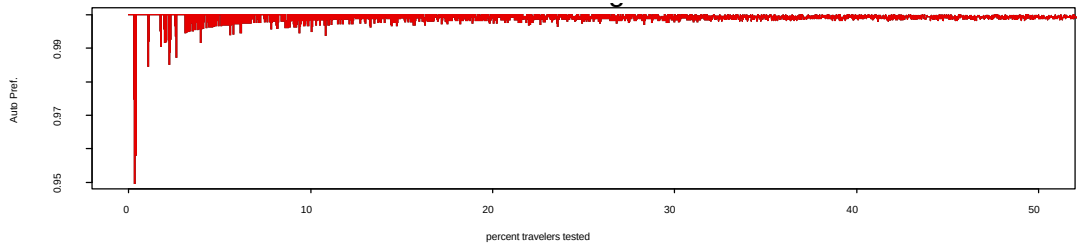
Percentage preferring auto

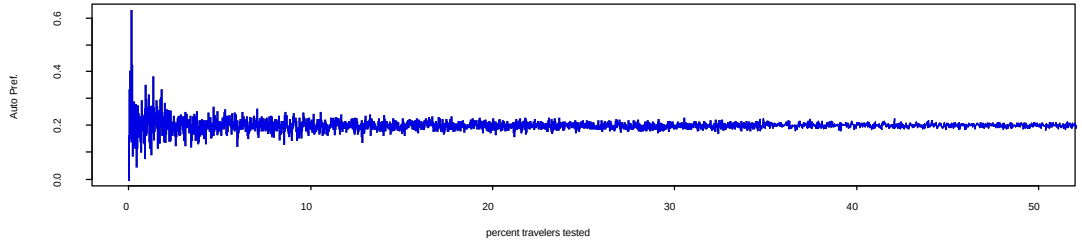
Overall percentage of total trips preferring auto:

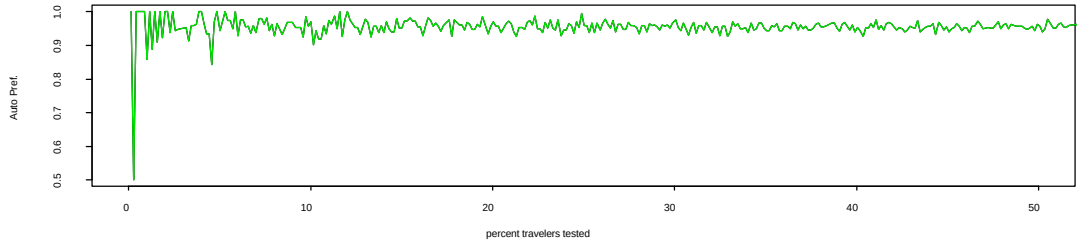
99% * 40% + 20% * 24% + 93% * 12% + 5% * 24% ~ 58%

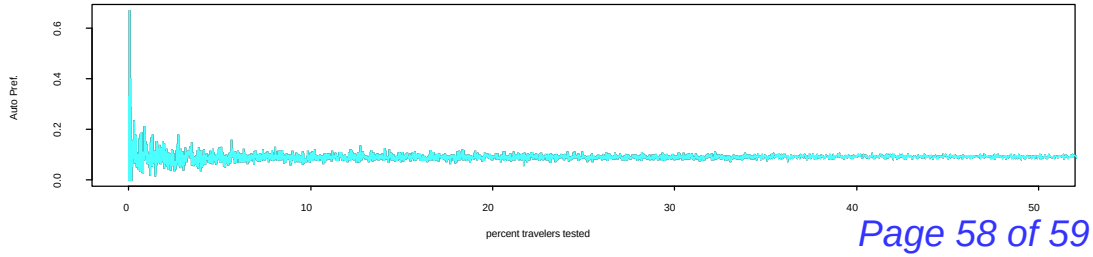
Small population, reduced transit

Cross River?	End in CBD?
No	No
No	Yes
Yes	No
Yes	Yes



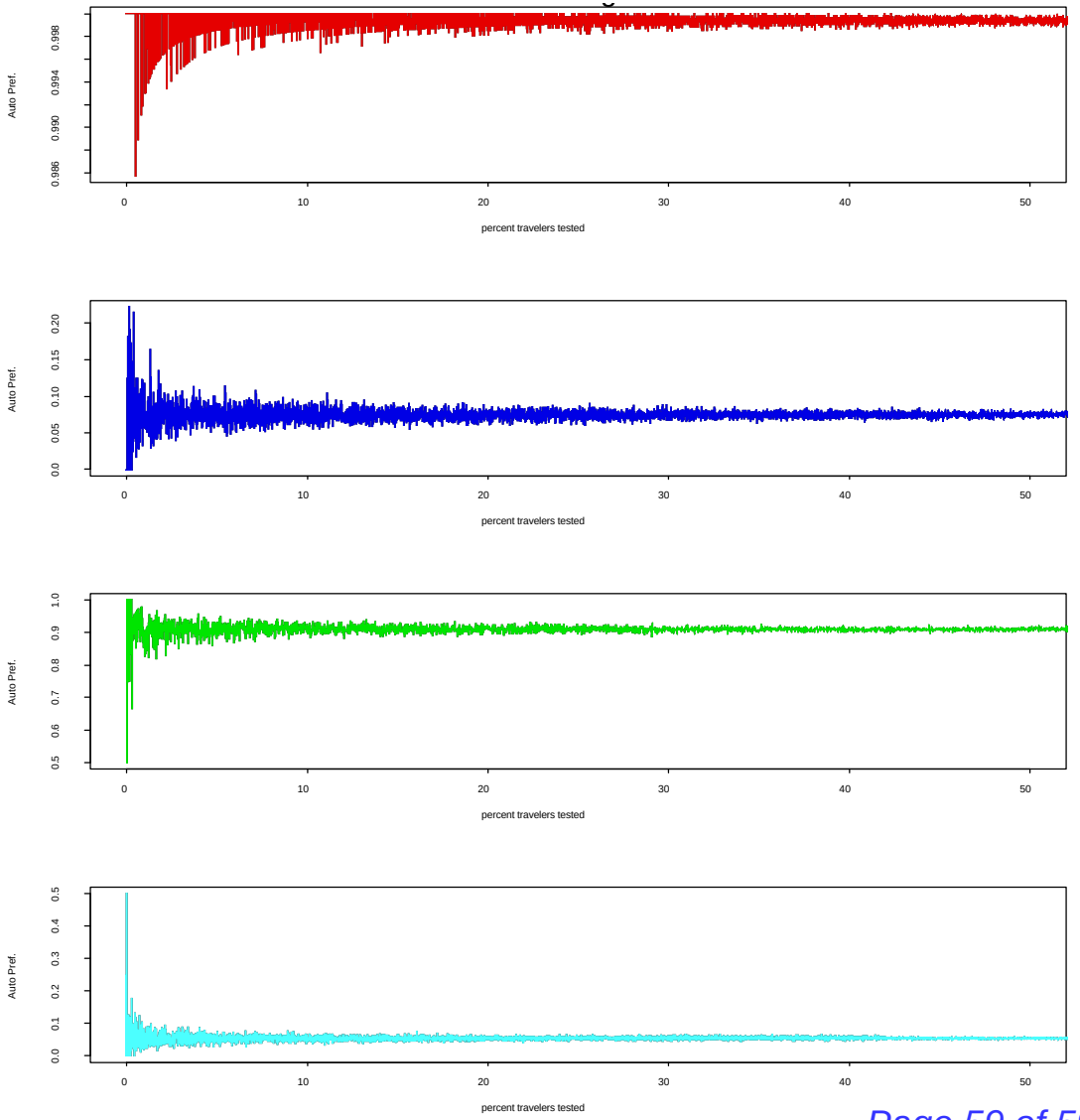






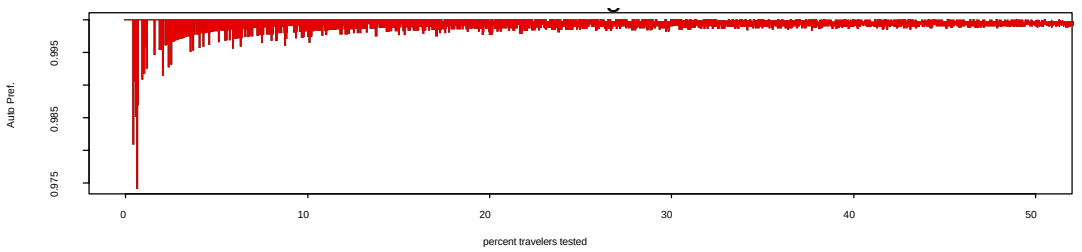
Big population, frequent transit

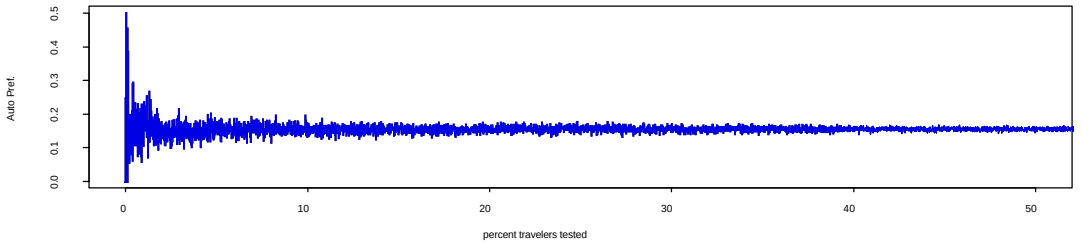
Cross River?	End in CBD?
No	No
No	Yes
Yes	No
Yes	Yes

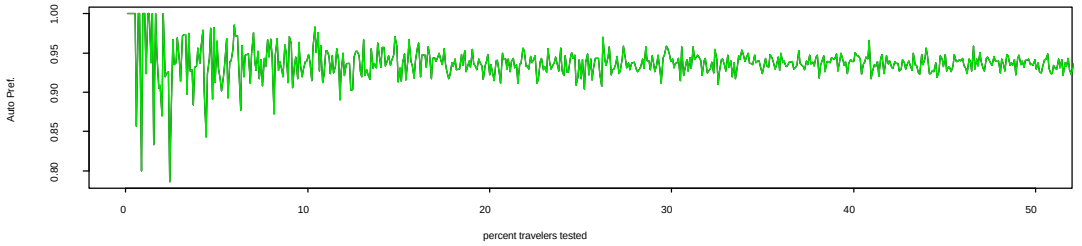


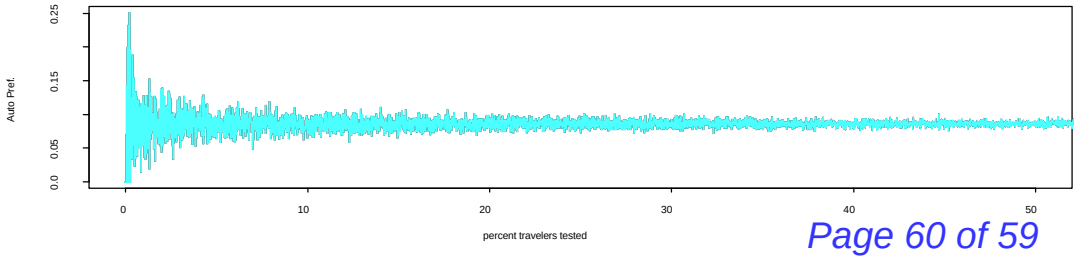
Big population, reduced transit

Cross River?	End in CBD?
No	No
No	Yes
Yes	No
Yes	Yes



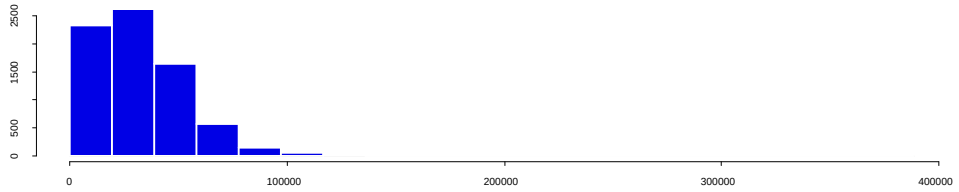




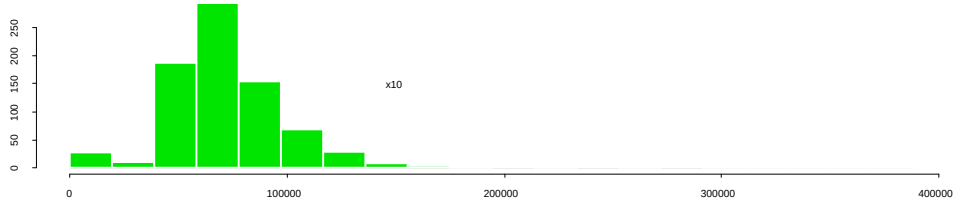


Who switches from transit? (by income)

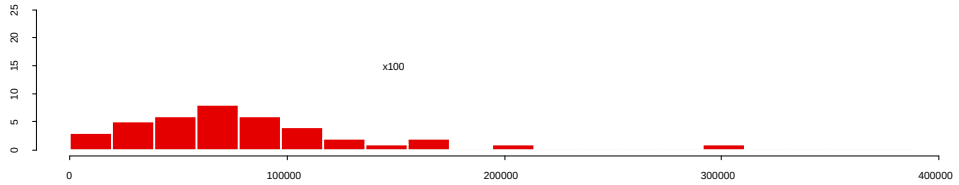
Stay on transit



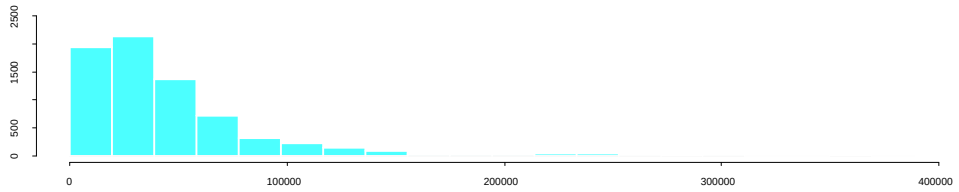
Switch to auto



Switch to transit

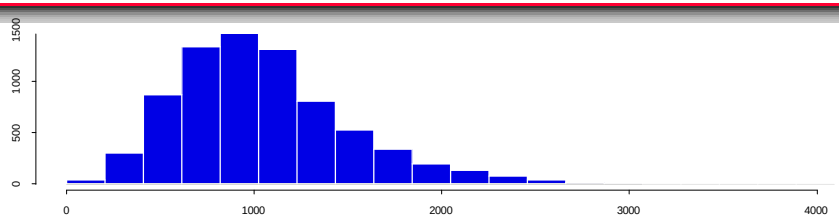


Stay in auto

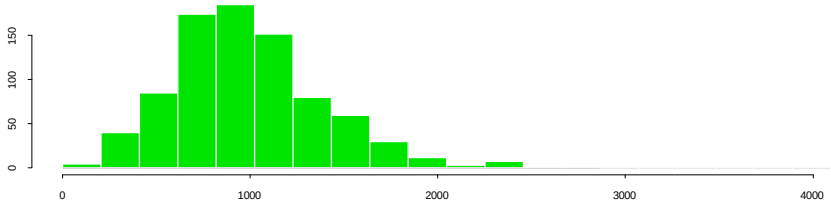


Who switches from transit? (by distance to transit stop)

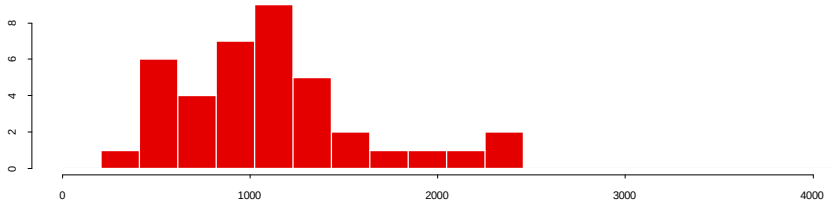
Stay on transit



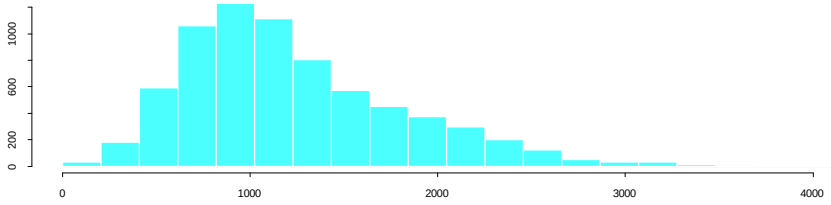
Switch to auto



Switch to transit



Stay in auto



Outline

- *The role of feedback In TRANSIMS*
- *The mechanics of feedback in TRANSIMS*
  - *Information Pathways*
  - *Tools*
    - *Collator*
    - *Stratifier*
    - *Selector*
- *A familiar feedback controller: the thermostat*
- *Examples*
  - *stabilization: traffic assignment*
  - *working around input problems*
  - *modeling: mode preference*
- *Discussion:*
  - *using TRANSIMS for equity studies*
  - *forecasting with TRANSIMS*

Conclusion

- *The TRANSIMS framework provides*
  - *feedback information pathways*
  - *tools for manipulating the information*
- *Feedback can be used to*
  - *calibrate component models*
  - *nudge the system into Nash equilibrium*
  - *forecast the response to changes subject to constraints*
  - *examine the demographics of affected travelers*
- *TRANSIMS does not provide cookbook recipes*
  - *each city has unique aspects*
  - *there are many approaches to doing each forecast*
  - *simulation is not a substitute for thought*